PE - Cap   **Photoelectric effect:**

(1) P.E. Current (For monochromatic light) ~ Intensity
(2) Stopping Voltage V_0 turned out to depend on ν.

⟶ The energy of a P-E ejected electron depends on ν of incident radiation

The dependence of current (# of electrons/unit time) Suggests that liberating an electron costs one Quantum ($=h\nu$) of energy. ⟹ Radiation is Quantized

$$K_{max} = \frac{1}{2} m v_{max}^2 = eV_0$$

Conservation of energy gives:

(1) $V_0 = \frac{h\nu}{e} - \frac{\phi_0}{e}$ ⟵ Work Function ⟺ Energy required to free an electron from a metal

How can this give us a threshold frequency, ν_{TH}, (Below which no electrons can be emitted)

$(V_0 = 0)$ $\nu_{TH} = \frac{\phi_0}{h}$

A Simple Example: Estimate ν_{TH} for Lithium

$\phi = 2.42\ eV$ (Per Electron) $eV = 1.6\times10^{-19} J$

$$\nu_{TH} = \frac{(2.42\ ev)(1.6\times10^{-19}\ J/ev)}{(6.63\times10^{-34}\ J\cdot s)} = 6.84\ Hz$$

$\lambda = \frac{c}{\nu_{TH}} = 514\ nm$ (Visible Blue-Green)

To Get $\frac{\#\ Photons}{m^2\cdot S}$: $\frac{Power}{Required\ e/electron} = \frac{1w}{(2.42ev)(1.6\times10^{-19}\ J/ev)}$

w/ Li ~ $eV_0 = (2.42\ eV)(1.6\times10^{-19}\ J/ev) = 3.87\times10^{-19} J$

$m_e = 9.1\times10^{-31}\ Kg$

$\frac{1}{2} m_e V_{max}^2 = eV_0$

⟶ $V_{max} = \sqrt{\frac{2eV_0}{m_e}}$

$= \sqrt{\frac{2(3.87\times10^{-19} J)}{9.1\times10^{-31} Kg}} = 9.2\times10^5\ m/s$ $(< cv)$

So how big of V_0 would result in nearly relativistic e^-?

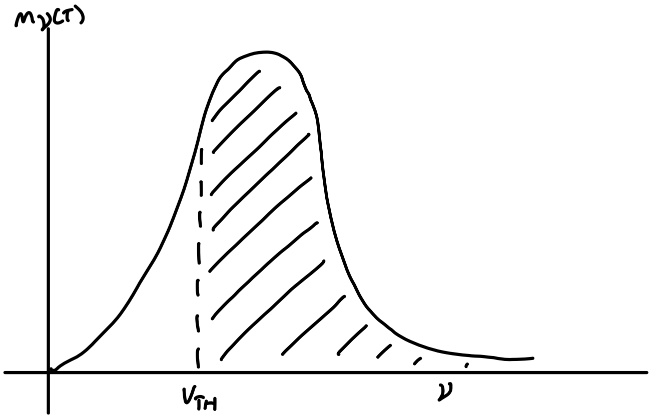
$V_{max} \approx 0.1c$

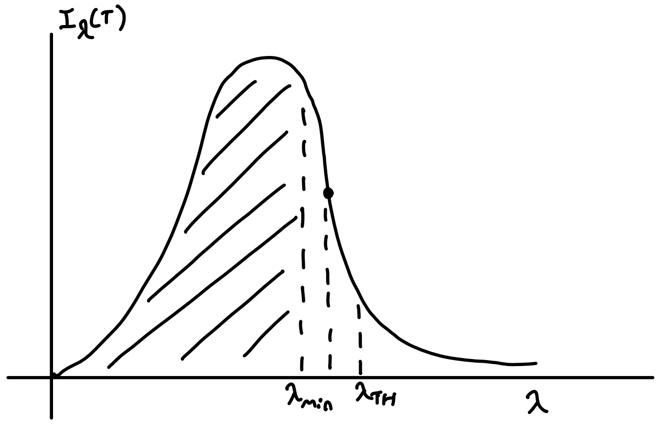
$$V_0 = \frac{1}{2}\frac{m_e}{e} V_{max}^2 = \frac{1}{2}\frac{m_e}{e}(3.0\times10^7\ m/s)^2$$

$$= \frac{1}{2}\frac{(9.1\times10^{-31}\ kg)}{(1.6\times10^{-19}\ J/ev)}(9.0\times10^{14}\ m^2/s^2)$$

$$= 2560\ ev \quad (X\text{-}Rays)$$

Let's Consider Illuminating A. Photocathode w/ A Blackbody Radiator. what can we Figure out?





$\frac{\#}{m^2 s} \sim$ Total M or I

$$\int_{\nu_{TH}}^{\infty} M_\nu(T)\, d\nu \qquad\qquad -\int_0^{\lambda_{TH}} I_\lambda(T)\, d\lambda$$

$\lambda_{TH} = 514 \text{ nm} \qquad \nu_{TH} = 5.84\times10^{14}\text{ Hz}$

What Frequencies bound the Band-Pass Filter?

$2\text{nm} = \Delta\lambda$

$\lambda_{min} = 513\text{ nm} \longrightarrow \nu_{max} = \frac{c}{\lambda_{min}} = 5.88\times10^{14}\text{ Hz}$

$\lambda_{max} = 515\text{ nm} \longrightarrow \nu_{min} = \frac{c}{\lambda_{max}} = 5.83\times10^{14}\text{ Hz}$

Photon Concept, Momentum, & X-Ray Production

Blackbody Radiation $\Rightarrow$ Demonstrates Energy Quantization
Photoelectric Effect $\Rightarrow$ Demonstrates that these Energy "Packets", or Quanta, appear to be real (..."Elements of Physical reality)

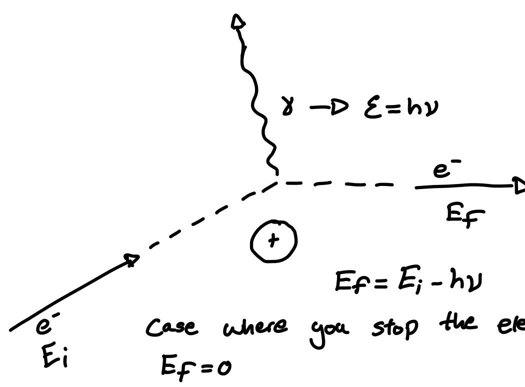
- When radiation interacts w/matter, it behaves like a particle

(When it interacts w/ other radiation, it behaves like a wave)

We might assume that there is an inverse process to the P.E. effect.

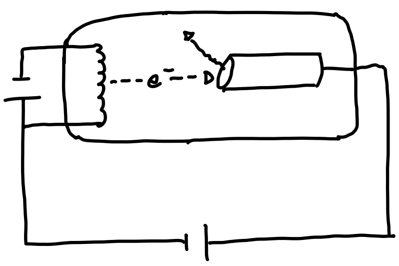
If a photon hits an atom & ejects an electron, the whole photon energy $h\nu$ is absorbed
(Ejected $e^- = h\nu$)

In the inverse process, this isn't so, energy is not quantized. It can stop & give up all K.E, or Scatter & give up some.



$E_f = E_i - h\nu$

Case where you stop the electron,
$E_f = 0$
$E_i = \frac{1}{2}mv^2 = eV_0 = h\nu_{max} = \frac{hc}{\lambda_{min}}$



Even for most metals with $\phi \sim$ A few eV, we can neglect this when estimating the min λ (max ν) in a Bremsstrahlung Process.

$\left(\frac{\phi}{35\text{kV}}\right) \ll 1$

$$\lambda_{min} = \frac{hc}{eV_0} = \frac{(6.63\times10^{-34}\text{ J}\cdot\text{s})(3.0\times10^{8}\text{ m/s})}{(1.6\times10^{-19}\text{ J/eV})(35.0\times10^{3}\text{ eV})} = 3.55\times10^{-11}\text{ m}$$